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RADIATION PROTECTION SPECIAL STUDY NO. 42-043-75
INFRARED HEAT LAMPS USED IN DRYING CHEMICAL SAMPLES
SEPTEMBER - OCTOBER 1974

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SERVING THE ARMY IN ITS PREVENTIVE MEDICINE PROGRAM

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US ARMY
ENVIRONMENTAL HYGIENE AGENCY
ABERDEEN PROVING GROUND, MD 21010

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)
A special study of the infrared heat lamps used in the Radiological and Biological Chemistry Division of the US Army Environmental Hygiene Agency to dry samples was conducted during the period September - October 1974. It was concluded that a personnel hazard from infrared radiation did not exist; however, continuous viewing of the light reflected from the planchette exceeds current recommended limits.

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DEPARTMENT OF THE ARMY
U. S. ARMY ENVIRONMENTAL HYGIENE AGENCY
ABERDEEN PROVING GROUND, MARYLAND 21010

HSE-RL

31 DEC 1974

RADIATION PROTECTION SPECIAL STUDY NO. 42-043-75
INFRARED HEAT LAMPS USED IN DRYING CHEMICAL SAMPLES
SEPTEMBER - OCTOBER 1974

ABSTRACT

A special study of the infrared heat lamps used in the Radiological and Biological Chemistry Division of the US Army Environmental Hygiene Agency to dry samples was conducted during the period September - October 1974. It was concluded that a personnel hazard from infrared radiation did not exist; however, continuous viewing of the light reflected from the planchette exceeds current recommended limits.

Recommendations include reducing reflected luminance from the sample planchette and placing a warning label on the sample dryer.

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DEPARTMENT OF THE ARMY
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HSE-RL/WP

31 DEC 1974

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1. REFERENCES.

a. Paragraph 2-35a(6), AR 10-5, Organization and Functions, Department of the Army, 28 January 1974.

b. AR 40-46, Control of Health Hazards from Lasers and Other High Intensity Optical Sources, 6 February 1974.

c. DF, USAEHA-RL, this Agency, 5 August 1974, subject: Evaluation of Heat Lamp Eye Hazard.

2. PURPOSE. To evaluate potential optical radiation hazards associated with the use of 250-watt infrared heat lamps in laboratory sample drying operations, to make recommendations designed to limit needless exposure of personnel to potentially hazardous radiation from this equipment, and to determine the need for eye protection for operators of this equipment.

3. BACKGROUND.

a. General. A 250-watt heat lamp was used in each Nuclear Associates Model 21-115 Sample Dryer (Figure 1) utilized for drying liquid samples in preparation for radio-chemical analysis. Personnel of the Radiological and Biological Chemistry Division of the US Army Environmental Hygiene Agency (USAEHA) using the lamps had complained of glare and eye strain from the lamps and were concerned about a potential eye hazard. One laboratory chemist wore Shade 2 filter glasses.

b. Instrumentation.

(1) Photo Research Pritchard Model 1980 Photometer.

(2) Nikon F Camera with Kodak Infrared Film.

(3) Hewlett-Packard Model 8330/8334A Radiant Flux Meter.

(4) EDP Scanning Photo-Microdensitometer.

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Figure 1. Nuclear Associates Sample Dryer Showing Metal Planchettes and Heat Lamp at Top of Page

c. Abbreviations. The Table of radiometric and photometric terms and units is provided in the Appendix.

d. Inventory. At the time of the study eleven units were in use at USAEHA. No attempt was made to determine numbers of similar units at Ft Belvoir and other Army laboratories.

4. FINDINGS.

a. Lamp Type. General Electric Model R40/10, 250-watt infrared heat lamp.

b. Irradiance. The maximum total irradiance at eye level within 30 cm - 100 cm from the Planchette ranged from 30 to 50 $\mu W \cdot cm^2$. If the lamp were directed upward the total irradiance was as shown in Figure 2. The reflected irradiance at eye level between 0.35 and 1.4 µm was approximately 7 percent of the total irradiance.

c. Spectral Distribution. The spectral distribution of each lamp had a maximum value at 1.2 - 1.3 µm.

d. Illuminance. The maximum illuminance measured at a distance of 1 meter with the lamp turned upward was 120 $lm \cdot ft^{-2}$.

e. Luminance. The maximum reflected luminance from the Planchette was 8 $cd \cdot cm^{-2}$.

f. Radiance. The radiance of the infrared heat lamps did not exceed 0.8 $W/cm^2 \cdot sr$ in the wavelength band of 0.4 to 1.4 µm.

5. DISCUSSION.

a. Skin Hazards. The warmth sensation by the skin resulting from absorption of radiant energy normally provides adequate warning to prevent thermal injury of the skin. The direct solar irradiance is approximately 40 to 70 $mW \cdot cm^{-2}$ in the northern latitudes and up to 100 $mW \cdot cm^{-2}$ in the tropics. These levels incident upon the skin produce a definite sensation of warmth. One could expect far-infrared radiation for wavelengths beyond 3 µm to cause a similar sensation for a whole-body irradiance of only 10 $mW \cdot cm^{-2}$, since the spectral absorption of visible and near-infrared is far less than for far-infrared radiation. Thresholds for thermal injury of the skin are far above these levels, hence no risk of skin burns exist from infrared radiation from the sample dryer.

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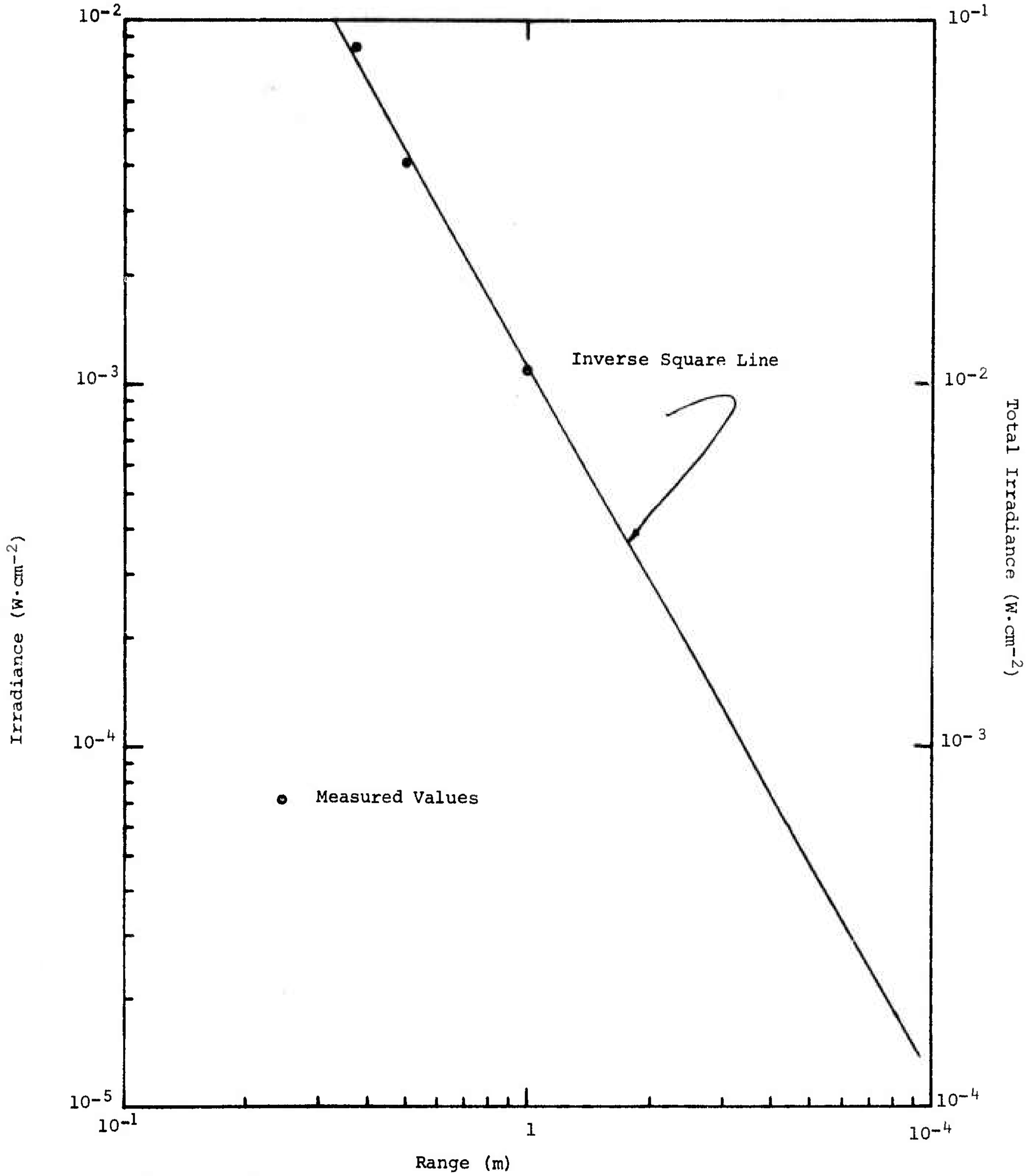

Figure 2. Left Scale; Irradiance vs. Range (0.4-1.4 μ), Right Scale; Total Irradiance vs. Range for the 250-W Heat Lamp

b. Eye Hazards from Infrared Radiation. Quantitative data for the production of lenticular opacities following exposure to infrared radiation are very limited. Radiant energy absorbed by the iris appears to play the principal role in raising the temperature of the crystalline lens for short exposure times. The infrared corneal dose-rate experienced out-of-doors in daylight is of the order of 10^{-3} $W \cdot cm^{-2}$. Some workers exposed for 10 to 15 years to infrared irradiances of 0.08 to 0.4 $W \cdot cm^{-2}$ encountered in the glass and steel industries have developed lenticular opacities. Such irradiances, even if visible radiation, definitely produce a marked sensation of warmth, provided that a significant area of the skin is exposed (greater than a few cm^2).

c. Eye Hazards from Intense Light. The radiance of the source is insufficient to cause thermal retinal injury. However, long-term staring into the lamp (not possible with present Nucleonics stand) or at the brilliant reflection from the planchette exceeds the current recommended limit of 1 $cd \cdot cm^{-2}$. Hence an OD-1 neutral filter would be necessary to reduce this reflection to a reasonably comfortable luminance.

d. Exposure Reduction. Two methods could be used to reduce the glaring reflection from the planchette.

(1) Reduce luminance using OD 1 or 10-percent transmission (Shade 3.5 to 4.0) filters either as an area shield (eg, dark plastic) or dark sunglasses.

(2) Reduce luminance by painting planchettes dark black. This, of course, may not be possible, since the paint may interfere with the sample.

6. CONCLUSIONS. Since the levels of infrared radiation measured very near the lamp exceeded comfortable levels for remaining under thermal exposure, and since the maximum levels measured were below those believed to thermally cause lenticular opacities for short exposure duration, it is concluded that a personnel hazard from infrared radiation did not exist. However, continuous viewing of the light reflected from the planchette exceeds current recommended limits.

7. RECOMMENDATIONS.

a. Place warning label on sample dryers to instruct viewers not to stare at the lamp or samples during operation.

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b. Reduce the reflected luminance from the planchette by providing Shade 3.5 - 4.0 sunglasses to laboratory personnel, or installing a filter shield around the dryers, or painting the planchettes black.

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APPENDIX

USEFUL CIE RADIOMETRIC AND PHOTOMETRIC TERMS AND UNITS[1, 2]

RADIOMETRIC				PHOTOMETRIC			
Term	**Symbol**	**Defining Equation**	**SI Unit and Abbreviation**	**Term**	**Symbol**	**Defining Equation**	**SI Units and Abbreviation**
Radiant Energy	Q_e		Joule (J)	Quantity of Light	Q_v	$Q_v = \int \Phi_v dt$	**lumen-second (lm·s) (talbot)**
Radiant Energy Density	W_e	$W_e = \frac{dQ_e}{dV}$	**Joule per cubic meter** $(J \cdot m^{-3})$	**Luminous Energy Density**	W_v	$W_v = \frac{dQ_v}{dV}$	**talbot per square meter** $(lm \cdot s \cdot m^{-3})$
Radiant Power (Radiant Flux)	Φ_e, P	$\Phi_e = \frac{dQ_e}{dt}$	**Watt (W)**	**Luminous Flux**	Φ_v	$\Phi_v = 680 \int \frac{d\Phi_e}{d\lambda} V(\lambda)\, d\lambda$	**lumen (lm)**
Radiant Exitance	M_e	$M_e = \frac{d\Phi_e}{dA} = \int L_e \cdot \cos\theta \cdot d\Omega$	**Watt per square meter** $(W \cdot m^{-2})$	**Luminous Exitance**	M_v	$M_v = \frac{d\Phi_v}{dA} = \int L_v \cdot \cos\theta \cdot d\Omega$	**lumen per square meter** $lm \cdot m^{-2}$
Irradiance or Radiant Flux Density (Dose Rate in Photobiology)	E_e	$E_e = \frac{d\Phi_e}{dA}$	**Watt per square meter** $(W \cdot m^{-2})$	Illuminance (luminous flux density)	E_v	$E_v = \frac{d\Phi_v}{dA}$	**lumen per square meter** $(lm \cdot m^{-2})$ **lux (lx)**
Radiant Intensity	I_e	$I_e = \frac{d\Phi_e}{d\Omega}$	**Watt per steradian** $(W \cdot sr^{-1})$	**Luminous Intensity (candlepower)**	I_v	$I_v = \frac{d\Phi_v}{dr}$	**lumen per steradian (lm·sr) or candela (cd)**
Radiance	L_e	$L_e = \frac{d^2\Phi_e}{d\Omega \cdot dA \cdot \cos\theta}$ [5]	**Watt per steradian and per square meter** $(W \cdot sr^{-1} \cdot m^{-2})$	**Luminance**	L_v	$L_v = \frac{d^2\Phi_e}{dr \cdot dA \cdot \cos\theta}$ [5]	**candela per square meter** $(cd \cdot m^{-1})$
Radiant Exposure (Dose, in Photobiology)	H_e	$H_e = \frac{dQ_e}{dA}$	Joule per square meter $(J \cdot m^{-2})$	Light Exposure	H_v	$H_v = \frac{dQ_v}{dA} = \int E_v dt$	lux-second (lx·s)
				Luminous Efficacy (of radiation)	K	$K = \frac{\Phi_v}{\Phi_e}$	**lumen per watt** $(lm \cdot W^{-1})$
				Luminous Efficiency (of a broad band radiation)	$V(*)$	$V(*) = \frac{K}{K_m} = \frac{K}{680}$	unitless
Radiant Efficiency[3] **(of a source)**	η_e	$\eta_e = \frac{P}{P_i}$	unitless	**Luminous Efficacy**[3] **(of a source)**	η_v	$\eta_v = \frac{\Phi_v}{P_i}$	**lumen per watt** $(lm \cdot W^{-1})$
Optical Density[4]	D_e	$D_e = -\log_{10} \tau_e$	unitless	Optical Density[4]	D_v	$D_v = -\log_{10} \tau_v$	unitless
				Retinal Illuminance in Trolands	E_t	$E_t = \frac{L_v}{S_p}$	troland (td) = luminance in $cd \cdot m^{-2}$ times pupil area in mm^2

1. The units may be altered to refer to narrow spectral bands in which case the term is preceded by the word *spectral*, and the unit is then per wavelength interval and the symbol has a subscript λ. For example, spectral irradiance H_λ has units of $W \cdot m^{-2} \cdot m^{-1}$ or more often, $W \cdot cm^{-2} \cdot nm^{-1}$.
2. While the meter is the preferred unit of length, the centimeter is still the most commonly used unit of length for many of the above terms and the nm or μm are most commonly used to express wavelength.
3. P_i is electrical input power in watts.
4. τ is the transmission
5. At the source $L = \frac{dI}{dA \cdot \cos\theta}$ and at a receptor $L = \frac{dE}{d\Omega}$